1 Reconfigurable Structure Control Experiment using the Modeling and Control Synthesis Toolbox (Iv ACSYN) *

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Abstract

This talk presents a *robust* control design experiment in a technology demonstration of Advanced Reconfigurable Control (ARC) using the integrated *Modeling and Control Synthesis Toolbox* (MACSYN) [1]. The objective of the experiment is to apply this integrated identification and robust synthesis methodology (MAC SYN) to the vibration suppression problem on an instrumented space truss structure. The overall methodology has been implemented and evaluated on a 4-input, 3-output non-colocated flexible structure at JPL. The identification method is based on a recent frequency domain technique which estimates both a state space model and an additive uncertainty weighting for multivariable robust control design. The control part is based on an dual-loop H^∞/H^2 approach with a hierarchical MIMO inner/outer loop design structure. This case study indicates that the integrated MACSYN design methodology provides an effective approach to developing vibration controllers for non-colocated space structures, or related applications involving multivariable plants of commensurate complexity.

Uncertainty is always the major issue in control system design. However, the proposed integrated MACSYN design method can precisely cast the uncertainty variations into its design process in advance so that the resulting multivariable controller will have robust performance in the presence of all these pre-identified uncertainties. To initiate this robust control design process, practical system ID algorithms play a crucial role in defining the nominal and uncertain space structure models. A systematic method for identification of both the nominal plant (in state-space form) and an uncertainty model (in parametric form) has been recently developed at JPL, based on frequency domain methods. The approach is based on a sequence of nonparametric and parametric steps using the theory and algorithms developed in [2, 3].

This overall app roach provides the information (plant estimate and uncertainty weightings) required for designing robust controllers using standard softw are/toolboxes, etc. After identifying the structure model and uncertainty boundaries, robust control synthesis methods such as H^2, H^∞, and μ-Synthesis [4] can be invoked to design a controller that stabilizes the plant and achieves disturbance rejection performance criterion based on the preset weighting functions. Altogether, system ID and robust control meth ods can be integrated in a highly efficient manner for this project as well as more challenging space missions in the future.

An H^∞/H^2 two-loop design methodology is proposed for the ARC experi ment. As described above, this method can provide an effective feedback controller by separating the robustness and perfor nance design issues into a hierarchical inner/outer loop closure process. The function of inner loop is to *shrink the ball of uncertainty*, so that the *loop-shaping* task of the outer loop can be rosily and effectively accomplished. In this unique ap p roach, H^2 and H^∞ optimizations are used independently and are complement ary to each other in a unified design fashion such that a robust and high performance controller is achieved without using the numerically ill-conditioned μ-Synthesis method.

The dual-loop controller can reject band-limited white noise (50 Hz) by a factor of 50 to 1 in the 4-input, 3-output non-colocated system. Preliminary laboratory results and simulation data have been included in this presentation. The final results together with several reconfigurable case studies will be published elsewhere.

References

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